

# Water Quality Changes Related to CUB Bulk Placement at the Rostraver Airport

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## ABSTRACT

A structural fill at the Rostraver Airport was constructed of Low Permeability Cementitious Material (LPCM), a stabilized product made from FGD, fly ash, quicklime and bottom ash. Five pre construction water samples were collected at six (3 up gradient and 3 down gradient) surface sampling points and at eight private residences near the airport. After the start of construction, samples were collected on a quarterly basis between January 2001 and December 2003. Discharge from the expansion area was sampled at two points. None of the water samples obtained at the up gradient and down gradient sampling points exceeded state mandated action levels or primary drinking water standards. A Scatterscore, based on the differences in the degree of overlap of the ranges of measured values and medians for all parameters, calculated for up/down gradient combinations indicated random change. Scatterscores of "Before" and "After" samples collected at the down gradient sampling points were more negative, due to the presence of several trace elements in the "After" samples that were not detected in the "Before" samples. In the samples collected at the private residences, none of the concentration values equaled or exceeded the action levels or PDW standards. The Scatterscore values indicated random change. Changes in water quality at the up gradient and down gradient sampling points and at residences near the Rostraver site are relatively small. They appear to be random and unrelated to the use of LPCM in the runway expansion project.

## INTRODUCTION

A structural fill at the Rostraver Airport was constructed of approximately 480,000 t of Low Permeability Cementitious Material (LPCM) supplied by the Elrama Power Station<sup>1-2</sup>. The LPCM is a stabilized product made from FGD, fly ash, quicklime and bottom ash. It was used under a general permit issued by the Pennsylvania Department of Environmental Protection (PADEP), which specified pre and post construction water quality monitoring at six (3 up gradient and 3 down gradient) surface sampling points (SP#). Water samples were also collected at eight private residences (R#) near the airport. Discharge from the expansion area was sampled at two points, the spring and toe drain. These water samples were analyzed at the National Energy Technology Laboratory (NETL), and the results were interpreted by the By-Product Utilization Research Group, which has extensive experience determining the release of metals from coal utilization by-products (CUB).

## METHODS AND MATERIALS

Water samples were collected at three up gradient sampling points (SP-1, SP-4, and SP-5) and three down gradient sampling points (SP-2, SP-3, and SP-6), as described in Table 1. Water samples were also taken at eight private locations at the request of the residents. A spring and the toe drain, influent to the sedimentation pond directly from the embankment, were also sampled.

Five background samples were collected between August and December, 2000 prior to the start of construction. After the start of construction, there were twelve sampling events on a quarterly basis between January 2001 and December 2003. The influent to the sedimentation pond at the embankment toe drain and at a spring in the toe area was also sampled on a quarterly basis.

The samples were analyzed for pH, alkalinity, conductivity, major cations (Al, Ca, Fe, K, Mg, Mn, Na), trace elements (As, B, Ba, Be, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Sb, Se, Sr, V, and Zn) by inductively coupled plasma-atomic emission spectroscopy (ICP\_AES), and anions (Cl, SO<sub>4</sub>) by ion chromatography. All analytical procedures were performed according to standard methods and following standard QA/QC procedures.

## RESULTS

Measured concentrations were compared to the action levels established by PADEP and to primary drinking water (PDW) standards. None of the water samples obtained at the up gradient and down gradient sampling points equaled or exceeded these values (Tables 2 and 3). There were several exceedances of secondary water standards (SDW) at both up gradient and down gradient sampling points for Al, Fe, Mn, and SO<sub>4</sub>. Generally, the frequency of exceedances was less in samples collected after placement of the CUB fill, especially at the down gradient points (Table 4).

The Scatterscore Water Quality Evaluation is a reconnaissance method to evaluate whether water quality changes at a site are positive, negative or random. In the Scatterscore method,<sup>3</sup> the analytical values for a given parameter at one point define a range of values that is compared to similar data for another sampling point. The range value ( $R_V$ ) evaluates the degree of overlap between two ranges. If the ranges completely overlap,  $R_V = 0.5$ . As the degree of overlap decreases, values of  $R_V$  increase. The range comparison ( $R_C$ ) is equal to  $R_V$  times  $\Delta Max$ , the difference in the maximum values for the up versus down or before versus after ranges is positive or negative. The ratio of medians (MR) for the up versus down gradient (or Before versus After) values is also calculated.

Plotting MR (x axis) and RC (y axis) as a scattergram is the basis for the calculation of a Scatterscore. Depending on the RC and MR values, a point for each element is plotted on a scattergram, in which the sections are defined as RC greater or less than 0 and MR greater than or less than 1. Scatterscores for each section are based on the number of points in that section and the difference between the average values and the values indicating no difference. The Scatterscore is calculated from the number of points and average RC and MR of each scattergram section.

$$SS_1 = n_1 * (\overline{RC}_1 - 0.5) * (1 - \overline{MR}_1)$$

$$SS_2 = n_2 * (\overline{RC}_2 - 0.5) * (\overline{MR}_2 - 1)$$

$$SS_3 = n_3 * (\overline{RC}_3 + 0.5) * (1 / \overline{MR}_3 - 1)$$

$$SS_4 = n_4 * (\overline{RC}_4 + 0.5) * (1 - 1 / \overline{MR}_4)$$

The Scatterscore is sum of the section scores. Values between -1 and 1 indicate random change; the degree of change becomes more significant as the values increase or decrease. Values between 2 and 10 or -2 and -10 indicate change in several elements. Values greater than 10 or less than -10 are usually related to changes in trace element concentrations

Calculated Scatterscores for all up gradient and down gradient combinations vary from -0.66 to 0.59; the average score is 0.06. These scores indicate that the overall change in water quality is random (Table 5). Scatterscores based on the comparison of “Before” and “After” samples collected at the down gradient sampling points (Table 6) exhibit a more negative trend (-0.81 to -6.06). The lower scores at the down gradient sampling points are due to the presence of several trace elements in the “After” samples that were below detection limits in the “Before” samples.

In the samples collected at the private residences in the area, none of the concentration values equaled or exceeded the action levels. Neither did any of the values exceed PDW standards, but several values, particularly for Al, exceeded SDW standards. The Scatterscore values for water samples collected from residential properties in the area, calculated as Before versus After, varied from -2.90 to 13.84; the average score is 0.89 (Table 7). Most of the scores represent random change in water quality. The high scores were related to relatively small decreases in the concentration of trace elements, particularly Cu and Zn. The low scores were due to higher concentrations of the major elements (Al, Fe, Cl) in the after samples.

Six water samples collected at the spring contained significantly more Ca and SO<sub>4</sub> than the average of the up gradient samples. The concentrations of K, Mn, Na and Mg were also higher than the average concentrations in the up gradient water. The elements, Ag and As, were detected in all of the samples from the spring; the concentration of As exceeded the PDW in all of the samples. Elevated concentrations of B were also consistently found in the spring samples. Scatterscores for the spring compared to the up gradient samples were between -21 and -47, indicative of the release of major and trace elements from the LPCM.

The 13 samples collected at the toe drain also contained elevated levels of Ca and SO<sub>4</sub>. Average levels of K, Mg, Mn, and Na were also higher than those in the up gradient samples. The average concentration of Fe is similar in both sets of samples, but the concentration of Al is lower in the toe drain samples. In 60% of the toe drain samples, Cd, which was not detected in the spring samples, was detected at concentrations slightly above the detection level. Elevated concentrations of B were found in all of the toe drain samples, and As was detected in two samples; both were at concentrations below the action level. The Scatterscores compared to the up gradient samples were between -4 and -20, due to the higher concentrations of major and

trace elements. Scatterscores calculated for the spring and toe drain versus the down gradient pond outfall (100 and 245) showed that water quality at the outflow was significantly improved.

## **SUMMARY**

At the Rostraver site, differences in water quality at the up gradient and down gradient sampling points are relatively small and appear to be random. Changes in water quality at residences near the Rostraver site also appear to be random and unrelated to the use of LPCM and bottom ash in the runway expansion project. The LPCM was probably the source of several elements (Ag, As, B, Cd) detected in the spring and toe drain samples, but was diluted to acceptable levels in the sedimentation pond.

These results are consistent with the results of leaching tests at NETL. Since most cations in materials derived from CUB in fly ash are present as oxides or as alumino-silicates,<sup>4</sup> they are just slightly soluble. Only Ca occurring as a sulfate, K and Na in clays exhibit aqueous solubility. At circum-neutral pH (between 5 and 8), the solubility of trace elements is very low, generally less than 2% of the amount present in the CUB.<sup>5</sup>

Table 1. Relative Location and Type of Water Sampling Locations.

<b>Monitoring Point</b>	<b>Relative Location</b>	<b>Type</b>
SP-1	Up gradient	Stream
SP-2	Down Gradient	Stream
SP-3	Down Gradient	Stream
SP-4	Up gradient	Stream
SP-5	Up gradient	Spring
SP-6	Down Gradient	Pond Outfall
R1	Up gradient	Well
R2	Up gradient	Well
R3	Up gradient	Well
R4	Up gradient	Spring
R5	Down Gradient	Well
R6	Down Gradient	Well
R7A		Cistern
R7B	Down Gradient	Spring
R7C	Down Gradient	Spring
R7D	Down Gradient	Pond Outfall
R7E	Down Gradient	Pond Outfall
R8	Up gradient	Spring

Table 2. Maximum (Max), minimum (Min), and median values for all parameters at up gradient sampling points. Blanks indicate that all values are below detection limits.

Parameter	SP1 (U1)			SP4 (U2)			SP5 (U5)		
	Max	Min	Median	Max	Min	Median	Max	Min	Median
Ag, mg/L									
Al, mg/L	7.160	0.013	0.105	1.86	0.003	0.069	0.373	0.028	0.080
As, mg/L									
B, mg/L	0.091	0.009	0.047	0.16	0.010	0.067	0.133	0.008	0.047
Ba, mg/L	0.243	0.071	0.100	0.09	0.017	0.070	0.129	0.063	0.101
Be, mg/L	0.001	0.000	0.000						
Ca, mg/L	90.500	45.600	75.300	86.60	24.700	69.400	88.500	40.900	72.630
Cd, mg/L	0.002	0.001	0.001	0.00	0.001	0.001	0.001	0.001	0.001
Co, mg/L	0.011	0.002	0.003	0.00	0.001	0.002	0.006	0.001	0.001
Cr, mg/L	0.021	0.002	0.003	0.02	0.002	0.005	0.006	0.002	0.003
Cu, mg/L	0.055	0.001	0.002	0.01	0.001	0.002	0.010	0.001	0.004
Fe, mg/L	16.300	0.044	0.120	2.33	0.003	0.073	1.630	0.028	0.084
K, mg/L	6.620	1.590	2.518	3.77	1.610	2.940	2.920	1.180	2.282
Mg, mg/L	24.222	12.600	21.700	24.00	11.400	18.400	24.203	12.200	21.200
Mn, mg/L	1.620	0.010	0.031	0.16	0.001	0.012	0.054	0.006	0.019
Mo, mg/L	0.006	0.002	0.004	0.02	0.003	0.004	0.004	0.003	0.003
Na, mg/L	79.980	27.490	35.700	162.23	24.300	47.500	53.184	15.400	26.415
Ni, mg/L	0.020	0.002	0.002	0.01	0.001	0.004	0.003	0.003	0.003
P, mg/L	0.856	0.015	0.061	0.11	0.008	0.042	0.070	0.011	0.029
Pb, mg/L	0.044	0.044	0.044						
S, mg/L	31.800	14.700	20.800	38.10	10.800	25.600	28.600	8.860	20.600
Sb, mg/L									
Se, mg/L	0.009	0.007	0.008	0.01	0.008	0.008	0.009	0.007	0.009
V, mg/L	0.029	0.002	0.008	0.01	0.002	0.002	0.015	0.002	0.009
Zn, mg/L	0.237	0.004	0.010	0.15	0.001	0.007	0.061	0.002	0.007
Hg, µg/L	0.059	0.001	0.006	0.05	0.002	0.004	0.095	0.001	0.005
pH, SU	8.44	6.52	7.87	8.62	6.41	8.11	8.16	6.41	7.66
Chloride, mg/L	178.35	1.80	56.90	274.15	45.70	77.50	1007.00	32.70	54.00
Sulfate, mg/L	67.70	32.00	56.89	100.60	30.20	73.40	65.80	41.10	58.65
Alkalinity, ppm as CaCO <sub>3</sub>	1034.00	136.25	182.68	268.07	109.80	154.82	217.20	100.70	192.27
Conductivity, microsiemens	1152.00	156.00	718.50	1450.00	215.00	904.50	1130.00	204.00	740.00

Table 3 . Maximum (Max), minimum (Min), and median values for all parameters at down gradient sampling points. Blanks indicate that all values are below detection limits.

Parameter	SP2 (D1)			SP3 (D2)			SP6 (D3)		
	Max	Min	Median	Max	Min	Median	Max	Min	Median
Ag, mg/L									
Al, mg/L	0.84	0.02	0.07	0.72	0.01	0.07	2.28	0.04	0.19
As, mg/L									
B, mg/L	0.12	0.01	0.05	0.13	0.02	0.07	0.05	0.01	0.04
Ba, mg/L	0.12	0.08	0.09	0.12	0.08	0.09	0.13	0.07	0.09
Be, mg/L	0.00	0.00	0.00				0.00	0.00	0.00
Ca, mg/L	93.20	53.80	78.30	85.10	53.60	74.30	86.10	53.00	72.30
Cd, mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Co, mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cr, mg/L	0.01	0.00	0.00	0.03	0.00	0.00	0.01	0.00	0.00
Cu, mg/L	0.02	0.00	0.00	0.02	0.00	0.00	0.04	0.00	0.00
Fe, mg/L	1.19	0.02	0.07	1.18	0.03	0.07	3.03	0.01	0.07
K, mg/L	3.23	1.57	2.30	3.86	1.62	2.49	2.97	1.59	2.30
Mg, mg/L	25.02	15.10	22.46	23.60	14.80	20.70	23.50	15.10	20.75
Mn, mg/L	0.05	0.00	0.01	0.05	0.00	0.01	0.20	0.00	0.02
Mo, mg/L	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Na, mg/L	58.95	24.50	27.60	87.95	25.30	31.81	67.45	18.30	25.10
Ni, mg/L	0.01	0.00	0.00	0.02	0.00	0.01	0.01	0.00	0.00
P, mg/L	0.06	0.01	0.03	0.10	0.02	0.03	0.12	0.02	0.03
Pb, mg/L							0.01	0.01	0.01
S, mg/L	39.80	16.90	22.45	38.30	17.00	23.60	29.70	14.20	20.70
Sb, mg/L									
Se, mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
V, mg/L	0.03	0.00	0.00	0.03	0.00	0.00	0.03	0.00	0.01
Zn, mg/L	0.15	0.00	0.01	0.04	0.00	0.01	0.05	0.00	0.01
Hg, µg/L	0.01	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.01
pH, SU	8.43	6.49	8.11	8.49	6.48	8.22	8.40	6.52	7.88
Chloride, mg/L	137.23	39.60	52.50	172.38	40.20	50.60	153.60	36.30	56.10
Sulfate, mg/L	91.70	43.90	61.61	87.60	50.40	63.90	1636.00	37.40	56.20
Alkalinity, ppm as CaCO <sub>3</sub>	794.00	18.32	200.60	979.00	21.08	192.03	292.60	165.95	192.38
Conductivity, microsiemens	1169.00	188.00	746.00	1319.00	216.00	761.00	4310.00	202.00	720.00

Table 4. Number and frequency of “Before” and “After” water samples exceeding secondary drinking water standards at up gradient and down gradient sampling points.

Location	Al (0.2 mg/L)			Fe (0.3 mg/L)			Mn (0.05mg/L)			Sulfate (250 mg/L)		
	Count	Before	After	Count	Before	After	Count	Before	After	Count	Before	After
SP1 (U1)	4	0.40	0.17	3	0.40	0.08	3	0.40	0.08	0		
SP2 (D1)	3	0.25	0.15	1	0.25	0.00	0			0		
SP3 (D2)	3	0.25	0.15	2	0.25	0.08	1	0.00	0.08	0		
SP4 (U2)	2	0.00	0.15	2	0.00	0.15	3	0.00	0.23	1	0.00	0.09
SP5 (U3)	2	0.25	0.08	2	0.25	0.08	2	0.00	0.15	1	0.00	0.10
SP6 (D3)	3	0.33	0.17	3	0.33	0.17	5	0.67	0.25	0		

Table 5. Section count, average values and Scatterscores for all combinations of up gradient and down gradient sampling points

	Section 1			Section 2			Section 3			Section 4			SS
	Count	RC	MR	Count	RC	MR	Count	RC	MR	Count	RC	MR	
U1vs D1	13	0.78	1.00	7	0.71	1.24	3	-0.64	0.94	4	-0.65	1.82	0.06
U1vs D2	12	0.79	1.00	6	0.70	1.59	5	-0.63	0.88	4	-0.67	1.06	0.59
U1vs D3	16	0.72	0.95	6	0.68	1.27	1	-0.58	0.96	4	-0.85	1.04	0.43
U2vs D1	9	0.71	1.00	8	0.65	1.32	1	-0.60	0.82	8	-0.65	1.02	0.35
U2vs D2	10	0.70	0.99	5	0.68	1.29	0	0.00	0.00	11	-0.65	1.03	0.23
U2vs D3	6	0.68	0.98	6	0.69	1.45	3	-0.58	0.50	11	-0.71	1.06	0.19
U3vs D1	8	0.63	1.00	3	0.76	1.07	6	-0.62	0.96	9	-0.78	1.38	-0.66
U3vs D2	7	0.60	0.95	4	0.73	1.12	5	-0.68	0.90	10	-0.73	1.22	-0.35
U3vs D3	7	0.65	0.99	3	0.71	1.12	3	-0.70	0.68	13	-0.76	1.03	-0.28

Table 6. Scatterscores of water quality changes at down gradient sampling points before and after placement of the CUB at the Rostraver site.

	Section 1			Section 2			Section 3			Section 4			SS
	Count	RC	MR	Count	RC	MR	Count	RC	MR	Count	RC	MR	
D1Bvs D1A	5	0.70	0.98	2	0.79	1.18	4	-0.90	0.69	15	-0.86	1.04	-0.81
D2Bvs D2A	4	0.84	0.97	2	0.71	1.17	4	-0.91	0.63	16	-0.84	1.06	-1.18
D3Bvs D3A	2	0.69	1.00	3	0.72	1.22	7	-0.92	0.45	14	-0.89	1.92	-6.06

Table 7. Scatterscores of water quality changes at private property sampling locations before and after placement of the CUB at the Rostraver site.

	Section 1			Section 2			Section 3			Section 4			SS
	Count	RC	MR	Count	RC	MR	Count	RC	MR	Count	RC	MR	
R1Bvs R1A	3	0.73	0.76	4	0.66	2.19	8	-0.71	0.69	10	-0.89	1.00	0.19
R2Bvs R2A	1	0.50	1.00	1	0.97	1.03	4	-0.77	0.72	17	-0.87	1.17	-1.32
R3Bvs R3A	5	0.93	1.00	2	0.88	1.02	2	-0.77	0.63	13	-0.94	1.20	-1.27
R4Bvs R4A	3	0.70	0.99	6	0.93	6.59	3	-0.73	0.53	9	-0.82	1.00	13.84
R5Bvs R5A	5	0.77	0.86	1	0.69	1.05	8	-0.82	0.67	11	-0.95	1.00	-1.10
R6Bvs R6A	6	0.79	0.83	3	0.78	4.22	6	-0.85	0.71	9	-0.82	1.34	1.36
R7ABvs R7AA	4	0.79	0.70	2	0.90	2.46	5	-0.78	0.54	11	-0.86	1.26	-0.47
R7BBvs R7BA	4	0.67	0.87	1	0.72	1.18	4	-0.68	0.73	13	-0.89	1.09	-0.54
R7CBvs R7cA	6	0.86	1.00	8	0.88	2.95	6	-0.83	0.69	4	-0.84	4.07	4.00
R7DBvs R7DA	3	0.67	0.72	2	0.83	1.19	6	-0.74	0.79	10	-0.90	1.13	-0.58
R7EBvs R7EA	5	0.63	0.83	1	0.61	1.58	8	-0.72	0.71	7	-0.87	1.00	-0.55
R8Bvs R8A	4	0.74	0.80	1	0.75	1.10	6	-0.87	0.74	14	-0.84	1.94	-2.90

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